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THE AQUATIC INSECT COMMUNITY IN PENITENTIARY GLEN, A PORTAGE ESCARPMENT STREAM IN NORTHEASTERN OHIO[1]

DAVID J. ROBERTSON,[2] Department of Biological Sciences, University of Pittsburgh, Pittsburgh, PA 15260

ABSTRACT. The aquatic insects inhabiting Penitentiary Glen, an isolated, high-gradient lotic habitat along Stoney Brook in Lake County, Ohio, were sampled during winter (December 1976), spring (May 1977), and summer (July 1977) months. Collections of immatures from dip nets and Surber samples were augmented with adult specimens taken in sweep nets and hand-picked from streamside rocks. Seventy-three species distributed among 60 genera in 7 orders were collected. Based on the diverse composition of the community dominated by organisms intolerant of organic enrichment, water quality in Stoney Brook is not significantly degraded. Community composition varies seasonally, with a trend toward a declining proportion of facultative organisms and increasing proportions of saproxenous and saprophobic organisms from winter through spring and into summer. Benthic diversity in Penitentiary Glen compares favorably with that in similar, relatively undisturbed northeastern Ohio streams, but the identity and proportional distribution of aquatic taxa varies considerably between streams.

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INTRODUCTION

The Portage Escarpment demarks the northern edge of the Allegheny Plateau in northeastern Ohio. A steep ridge paralleling the southern shoreline of Lake Erie reveals the location of the escarpment which extends westward from Ashtabula Co. into Lake and Cuyahoga Counties. South of the escarpment, the Mississippian bedrock of the plateau was repeatedly eroded by advances of Pleistocene glaciation. Outwash and moraines subsequently filled depressions in the plateau with glacial drift leaving a broad, poorly drained and gently rolling landscape. North of the escarpment, the Lake Plain lies in a narrow band that extends to the present shoreline of Lake Erie (Masteller et al. 1976).

The escarpment itself is topographically distinct. Over a distance of approximately one km, elevation climbs from 240 m at the base to over 300 m at the crest. Streams draining the highlands have excavated narrow gorges into the edge of the plateau in their descent to Lake Erie. Between the Grand River and its tributaries on the northeast and the Cuyahoga Valley on the west, the streams have created a series of steep-gradient lotic habitats isolated from one another by intervening stretches of low-relief Lake Plain and plateau terrain.

Stoney Brook valley is characteristic of the deeply incised streams of the escarpment (fig. 1). The brook's headwaters rise on glacial drift at an elevation of 330 m in Kirtland Twsp., Lake Co., 5.8 km southeast of the village of Kirtland. Initially, the stream flows northward through beech-sugar maple woodland, open fields and suburban development. Gradient in the upper portion of the watershed averages 9.0 m/km.

At a point 3 km from its source, the stream veers to the northwest and plunges over a fall into a 0.8-km long ravine known as Penitentiary Glen. The Glen, now a unit of the Lake Co. Metropolitan

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[2]Present Address: Florida Institute of Phosphate Research, 1855 West Main Street, Bartow, FL 33830

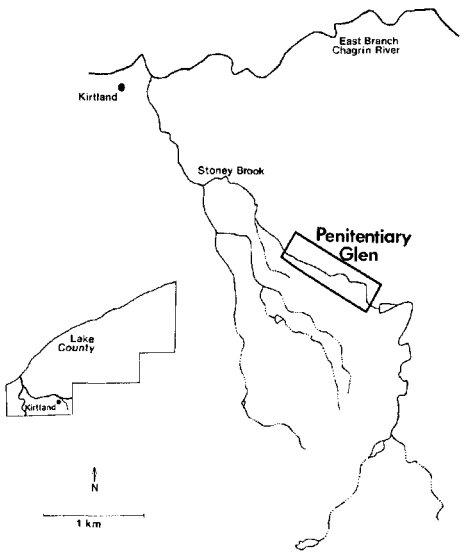

FIGURE 1. Location map of Penitentiary Glen, Lake County, Ohio.

Park District, is a sheer-walled gorge that formerly harbored fugitives from the Mormon settlement in Kirtland seeking to escape conscription and incarceration. The walls of the ravine are composed of Mississippian Berea sandstone underlain by Bedford shales and thin interbedded sandstone (Prosser 1912). Through the gorge the stream drops over 60 m, flowing over a series of small falls which have developed where shales have crumbled beneath more resistant sandstone beds. Vegetation is restricted to a relict hemlock forest hugging the rim of the gorge.

From the Glen's western end to the confluence with the east branch of the Chagrin River at Kirtland, Stoney Brook flows over harder Upper Devonian shales of the Chagrin Formation. A Mixed Mesophytic forest covers the gentler slopes of the lower stream valley. The overall relief of the stream is 135 m at an average gradient of 23 m/km.

METHODS AND MATERIALS

Qualitative aquatic insect samples were collected from Stoney Brook within Penitentiary Glen during December 1976 using a long-handled aquatic dip net. During May and July 1977, a Surber sampler (571 μ mesh aperature) was used. The collections, consisting primarily of immature insects, were augmented with adult specimens taken in sweep nets and hand-picked from streamside rocks. Samples were preserved in 70% ethanol. Insects were identified to the species level where possible, or to type if specific keys were not available. The author retains a majority of the collection, although voucher specimens of several plecopteran and ephemeropteran species are on deposit in the collection of the Kansas Biological Survey.

RESULTS

A total of 73 species (or types) of aquatic insects were identified from Penitentiary Glen (table 1). The species are distributed among 60 genera in 7 orders. In general, it was possible to identify the immatures of the smaller and better-known orders (Plecoptera, Ephemeroptera, Odonata) to the specific level, whereas many of the caddisfly (Trichoptera) and dipteran larvae could only be recognized as types. Table 1 also contains information on the number of individuals that were collected during each sampling trip. However, since the collection efforts cannot be quantified between sampling dates, these data are provided only as indications of relative abundance.

DISCUSSION

Despite the fact that no direct measurements of water quality are available, the diverse aquatic insect community in Penitentiary Glen is indicative of a stream that has not been severely disturbed. Fig. 2 shows the proportional distribution of all facultative, saproxenous, and saprophobic organisms in Penitentiary Glen for which pollution tolerance information is available (Paine and Gaufin 1956, Gaufin 1958, Beck 1977, Hubbard and Peters 1978, Surdick and Gaufin 1978). Saprophilic organisms are restricted to heavily enriched habitats characteristic of the degraded zones below sewage outfalls. Facultative species are found in polluted as well as clean water. Saproxenous organisms are most abundant in clean water, although they can tolerate limited organic loading. Finally, saprophobic species are restricted to water that is not polluted. Distributions are shown for individual collections and for combined collections.

TABLE 1

Aquatic insect collection records for Penitentiary Glen.

Taxa	No. of Individuals Dec '76	May '77	July '77
Ephemeroptera			
Family Siphlonuridae			
Ameletus lineatus Traver	—	2	2
Family Baetidae			
Baetis flavistriga McDunnough	10	812	—
B. tricaudatus Dodds	45	177	39
Family Heptageniidae			
Epeorus (Iron) pleuralis (Banks)	—	2	—
Heptagenia sp.	4	9	—
Stenacron interpunctatum Jensen	—	15	15
Stenonema femoratum (Say)	8	1	—
S. terminatum terminatum (Walsh)	—	1	—
S. vicarium (Walker)	—	2	—
Family Leptophlebiidae			
Leptophlebia sp.	11	1	—
Paraleptophlebia adoptiva (McDunnough)	11	—	—
P. mollis (Eaton)	—	954	23
P. ontario (McDunnough)	—	12	15
Family Ephemerellidae			
Eurylophella minimella (McDunnough)	2	15	—
Drunella cornutella (McDunnough)	—	1	—
Family Ephemeridae			
Ephemera sp.	—	1	1
Odonta			
Family Calopterygidae			
Calopteryx maculata (Beauvois)	—	3	—
Plecoptera			
Family Nemouridae			
Amphinemura delosa (Ricker)	3	200	1
Soyedina vallicularia (Wu)	2	—	—
Family Leuctridae			
Leuctra tenuis (Pictet)	—	451	456
Family Perlodidae			
Cultus decisus (Walker)	4	19	—
Isoperla namata Frison	—	2	—
Family Chloroperlidae			
Alloperla chloris Frison	—	11	1
Family Perlidae			
Acroneuria abnormis (Newman)	—	1	1
A. carolinensis (Banks)	3	6	5
A. lycorias (Newman)	—	—	5
Megaloptera			
Family Corydalidae			
Nigronia fasciatus (Walker)	—	—	1
Family Sialidae			
Sialis sp. Latreille	1	—	2
Trichoptera			
Family Philopotamidae			
Chimarra atterima Hagen	—	2	—
Family Polycentropidae			
Neureclipsis bimaculata (L.)	—	1	—
Polycentropus maculatus Banks		6	
Family Hydropsychidae			
Cheumatopsyche sp_1	5	4	107
Cheumatopsyche sp_2	2	—	—

TABLE 1—*Continued*

Aquatic insect collection records for Penitentiary Glen.

Taxa	No. of Individuals Dec '76	May '77	July '77
Diplectrona modesta Banks	2	140	50
Hydropsyche betteni Ross	3	11	3
Symphitopsyche slossonae (Banks)	—	9	38
Family Rhyacophilidae			
Rhyacophila banksi Ross	—	1	—
R. carolina Banks	6	17	—
R. carpenteri Milne	—	—	6
Family Limnephilidae			
Neophylax concinnus McLachlan	—	—	8
Coleoptera			
Family Dytiscidae			
Bidessus sp.	1	—	—
Derovatellus lentus Sharp	—	1	—
Hydaticus sp.	—	—	1
Family Elmidae			
Ancyronyx variegata (Germar)	—	1	—
Dubiraphia bivittata (Le Conte)	—	24	9
Family Psephenidae			
Ectopria nervosa (Melsheimer)	—	—	10
Psephenus herricki (DeKay)	—	—	10
Diptera			
Family Tipulidae			
Tipula sp.	2	—	—
Family Chironomidae/Tanypodinae			
Conchapelopia sp.	—	108	43
Larsia sp.	—	—	6
Nilotanypus sp.	—	—	1
Zavrelimyia sp.	—	7	11
Family Chironomidae/Diamesinae			
Diamesa sp.	—	3	1
Pagastia sp.	—	2	7
Family Chironomidae/Orthocladiinae			
Chaetocladius sp.	4	—	1
Corynoneura sp.	—	—	2
Cricotopus sp.	—	1	4
Eukiefferiella sp.	—	14	107
Parametriocnemus sp.	14	37	113
Rheocricotopus sp.	—	4	
Synorthocladius sp.	—	1	8
Thienemanniella sp.	—	—	3
Family Chironomidae/Chironominae			
Cryptochironomus sp.	—	1	1
Microtendipes sp.	1	—	—
Polypedilum sp_1	2	3	13
Polypedilum sp_2	—	42	56
Polypedilum sp_3	—	13	24
Rheotanytarsus sp.	—	1	5
Stempellinella sp.	—	—	1
Tanytarsus sp.	—	—	6
Family Athericidae			
Atherix variegata Walker	1	—	—
Family Syrphidae			
Neoascia globosa (Walker)	1	—	—

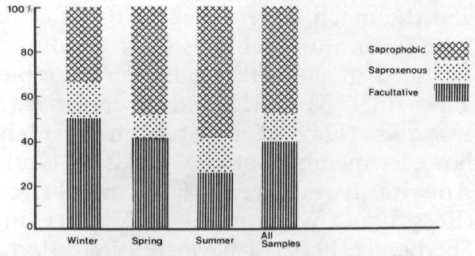

FIGURE 2. Proportional composition by season of the benthic insect community in Penitentiary Glen in relation to organic pollution tolerance.

No saprophilic organisms (e.g. tubificids, pulmonate snails and some "bloodworm" midge larvae) were present in any of the collections. These organisms are the most abundant and often nearly exclusive inhabitants of organically enriched streams where low levels of dissolved oxygen have eliminated intolerant predators and competing species, releasing population controls on a few tolerant species (Olive 1976). The complete lack of saprophilic organisms is additional evidence of high water quality in the stream.

Few of the species inhabiting Penitentiary Glen are facultative organisms. However, those that are present comprise a significant proportion (38%) of the community on an annual basis. The mayflies *Baetis tricaudatus* and *B. flavistriga* and a species of the caddisfly genus *Cheumatopsyche* are the most abundant of the facultative insects. All 3 species were collected during each of the sampling trips, indicating that they are significant components of the community throughout the year.

Saproxenous species are less abundant than the facultative organisms, making up only 11% of the community. However, a larger number of species are saproxenous than facultative. *Amphinemura delosa* and the 3 species of *Polypedilum* are the most abundant saproxenous organisms, although the carnivorous stonefly *Acroneuria carolinensis* was collected throughout the year in low numbers befitting its trophic status.

Saprophobic insects are the largest component of the invertebrate community. Over half (51%) of the organisms collected from Penitentiary Glen are restricted to clean water with very little or no organic enrichment. Many of the saprophobic species are represented by few individuals, but several are present in large numbers. The most common are the mayflies *Stenacron interpunctatum, Paraleptophlebia mollis, P. ontario,* the caddisfly *Symphitpsyche slossonae,* the riffle beetle *Stenelmis lateralis,* and the orthoclad midges *Eukieferiella* sp. and *Parametriocnemus* sp. These 7 species comprise nearly 90% of all the saprophobic insects inhabiting the stream.

Petersen and Foote (1980) note that in northeastern Ohio, the caddisfly *Rhyacophila carolina* is found only in streams of the highest water quality. *R. carolina* occurs in Penitentiary Glen, where it is associated with several other intolerant congeners indicative of excellent water quality. The poorly known chironomid genus *Pagastia,* apparently restricted to the cleanest of waters and occurring in greatest numbers in high-gradient stenothermal streams (L. C. Ferrington, pers. comm. 1984) was also collected from Penitentiary Glen during the spring and summer.

There is a trend toward a declining proportion of facultative organisms and increasing proportions of saproxenous and saprophobic organisms from winter through spring and into summer. The trend may reflect seasonal variations in the aquatic community, but a second explanation may be that the net used to make the winter collection had larger mesh than that used to make the spring and summer collections. The larger mesh biased the samples toward larger organisms, allowing small larvae (especially chironomids) to escape. Because the vast majority (73%) of the midge species collected from Penitentiary Glen are saprophobic, and because chironomids comprise a smaller percentage of the total collection in the winter sample than any other, the predom-

inance of facultative organisms is probably an artifact of the larger net mesh.

Nymphs and larvae of stoneflies, mayflies, caddisflies and midges are integral components of the benthic fauna of most relatively undisturbed streams (Hynes 1960, Olive 1976). Because of their species-specific environmental requirements and narrow tolerance of fluctuations in environmental conditions, these organisms reflect the physical, chemical and biological nature of the environment. The diverse assemblage in Penitentiary Glen indicates relatively high water quality, yet the proportional distribution of individual organisms among taxonomic groups is different from that which has been reported from other streams in the area.

Olive (1976) found a diverse community of benthic organisms inhabiting a relatively undisturbed portion of the upper Cuyahoga River at Hiram Rapids. The benthic community in Penitentiary Glen is far more diverse than Olive found in the Cuyahoga, and differs significantly in composition. Compositional differences between Penitentiary Glen and the upper Cuyahoga River are most likely due to differences in substrate, gradient, and channel configuration between streams, but isolation and the notoriously poor vagility of many aquatic insects serve to further enhance the uniqueness of the invertebrate communities.

Another possible source of difference in communities inhabiting similar streams located in close proximity may be the method of making collections. Tkac (1973) made extensive collections of aquatic insects from Stebbin's Gulch, a stream almost identical to Penitentiary Glen 3.5 km to the northeast. Tkac's collections consist exclusively of adult material obtained in sweep nets, picked from streamside rocks, and taken in black light traps. In addition, Tkac made collections from all parts of the gorge, from the upstream end to its mouth at the Chagrin River. It is possible that vagile adults from habitats in the low-gradient headwaters and the much larger Chagrin River could have flown into Stebbin's Gulch and were included in the collections. For example, Tkac (1973) collected *Macrostemum zebratum* (Hagen) in Stebbin's Gulch, however members of this genus in North America are restricted to large, rapid rivers (Ross 1944, Wiggins 1977, Wallace and Sherberger 1974). I have collected *Macrostemum* in northwestern Pennsylvania streams comparable in size to the Chagrin River but never in streams as small as Stebbin's Gulch or Penitentiary Glen. It is altogether possible that the species list for Stebbin's Gulch inadvertently contains organisms from outside the stream itself. In contrast, the Penitentiary Glen list was developed almost exclusively from immatures collected directly from the stream at the mid-point of the gorge which is relatively isolated from both the headwaters and the mouth. Additional collections would undoubtedly augment the Penitentiary Glen species list, but the community in the stream would not be identical to that recorded from Stebbin's Gulch.

Few of the streams along the escarpment are afforded the complete protection that is critical for the maintenance of high water quality and a diverse benthic community. Stebbin's Gulch, with nearly all of its watershed within the boundaries of the Holden Arboretum, is the exception rather than the rule. Stoney Brook represents the more typical situation: the scenic main stream flows within the protected boundaries of parkland, but the tributaries, not afforded the same protection, are subject to erosion, polluted runoff, and septic tank wastes as suburban development encroaches into the watersheds. This scenario is applicable to nearly all of the major tributaries of the lower Cuyahoga River. Fortunately, the tributaries of the Chagrin and Grand Rivers along the escarpment generally have fared more favorably, although water quality cannot be assured.

Most of the escarpment streams are small, and impacts will be most likely

limited to subtle effects from gradual enrichment and erosion rather than severe or acute disturbances caused by chemical toxins and sewage plant discharges. Nevertheless, changes in the benthic communities will reflect alterations in water quality.

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EDITOR'S NOTE

New manuscripts usually will be published within 7 months of acceptance in *The Ohio Journal of Science.*